

WHAT IS CLAIMED IS:

1. A laser irradiation apparatus comprising:
  - a first laser oscillator generating a first pulsed laser beam having a wavelength
  - 5 at which an absorption coefficient to the processing object is  $1 \times 10^4 \text{ cm}^{-1}$  or more;
  - means for controlling a shape and a position of a beam spot of the first laser beam;
  - a second laser oscillator generating a second continuous wave laser beam;
  - means for controlling a shape and a position of a beam spot of the second laser
  - 10 beam to overlap with the beam spot of the first laser beam; and
  - means for controlling a relative position of the beam spot of the first laser beam and the beam spot of the second laser beam to the processing object.
2. A laser irradiation apparatus according to claim 1,
- 15 wherein the first laser beam has a wavelength of second harmonic.
3. A laser irradiation apparatus according to claim 1,
- wherein the second laser beam has a wavelength of fundamental wave.
4. A laser irradiation apparatus according to claim 1,
- 20 wherein the beam spot of the first laser beam is elliptical, rectangular, or linear.
5. A laser irradiation apparatus according to claim 1,
- 25 wherein the beam spot of the second laser beam is elliptical, rectangular, or linear.
6. A laser irradiation apparatus according to claim 1,
- wherein the first laser oscillator is selected from the group consisting of an Ar
- 30 laser, a Kr laser, an excimer laser, a  $\text{CO}_2$  laser, a YAG laser, a  $\text{Y}_2\text{O}_3$  laser, a  $\text{YVO}_4$  laser, a YLF laser, a  $\text{YAlO}_3$  laser, a glass laser, a ruby laser, an alexandrite laser, a Ti: sapphire laser, a copper vapor laser, and a gold vapor laser.
7. A laser irradiation apparatus according to claim 1,
- 35 wherein the second laser oscillator is selected from the group consisting of an

Ar laser, a Kr laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, an alexandrite laser, a Ti: sapphire laser, and a helium-cadmium laser.

5           8. A laser irradiation apparatus according to claim 1,  
          wherein:  
          the processing object comprises a substrate having a thickness of "d" which is  
transparent to the first laser beam; and  
          an incident angle " $\phi 1$ " of the first laser beam to a surface of the processing  
object satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined as a length  
10       of a major axis or a minor axis of the beam spot of the first laser beam.

          9. A laser irradiation apparatus according to claim 1,  
          wherein:  
          the processing object comprises a substrate having a thickness of "d" which is  
15       transparent to the second laser beam; and  
          an incident angle " $\phi 2$ " of the second laser beam to a surface of the processing  
object satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined as a length  
of a major axis or a minor axis of the beam spot of the second laser beam.

20           10. A laser irradiation apparatus comprising:  
          a first laser oscillator generating a first pulsed laser beam having a wavelength  
of visible light or a shorter wavelength than that of visible light;  
          means for controlling a shape and a position of a beam spot of the first laser  
beam;  
25           a second laser oscillator generating a second continuous wave laser beam;  
          means for controlling a shape and a position of a beam spot of the second laser  
beam to overlap with the beam spot of the first laser beam; and  
          means for controlling a relative position of the beam spot of the first laser  
beam and the beam spot of the second laser beam to a processing object.

30           11. A laser irradiation apparatus according to claim 2,  
          wherein the first laser beam has a wavelength of second harmonic.

          12. A laser irradiation apparatus according to claim 2,  
35       wherein the second laser beam has a wavelength of fundamental wave.

13. A laser irradiation apparatus according to claim 2,  
wherein the beam spot of the first laser beam is elliptical, rectangular, or  
linear.

5

14. A laser irradiation apparatus according to claim 2,  
wherein the beam spot of the second laser beam is elliptical, rectangular, or  
linear.

10

15. A laser irradiation apparatus according to claim 2,  
wherein the first laser oscillator is selected from the group consisting of an Ar  
laser, a Kr laser, an excimer laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser,  
a YLF laser, a YAlO<sub>3</sub> laser, a glass laser, a ruby laser, an alexandrite laser, a Ti: sapphire  
laser, a copper vapor laser, and a gold vapor laser.

15

16. A laser irradiation apparatus according to claim 2,  
wherein the second laser oscillator is selected from the group consisting of an  
Ar laser, a Kr laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a  
YAlO<sub>3</sub> laser, an alexandrite laser, a Ti: sapphire laser, and a helium-cadmium laser.

20

17. A laser irradiation apparatus according to claim 2,  
wherein:  
the processing object comprises a substrate having a thickness of "d" which is  
transparent to the first laser beam; and  
an incident angle " $\phi 1$ " of the first laser beam to a surface of the processing  
object satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined as a length  
of a major axis or a minor axis of the beam spot of the first laser beam.

25

30

18. A laser irradiation apparatus according to claim 2,  
wherein:  
the processing object comprises a substrate having a thickness of "d" which is  
transparent to the second laser beam; and  
an incident angle " $\phi 2$ " of the second laser beam to a surface of the processing  
object satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined as a length  
of a major axis or a minor axis of the beam spot of the second laser beam.

35

19. A laser irradiation method comprising the step of;  
irradiating a processing object with a first pulsed laser beam having a  
wavelength at which an absorption coefficient to the processing object is  $1 \times 10^4 \text{ cm}^{-1}$  or  
5 more and a second continuous wave laser beam,  
wherein when the first laser beam and the second laser beam are irradiated, a  
beam spot formed on a surface of the processing object by the first laser beam and a  
beam spot formed on the surface of the processing object by the second laser beam are  
overlapped.
- 10 20. A laser irradiation method according to claim 19,  
wherein the first laser beam has a wavelength of second harmonic.
- 15 21. A laser irradiation method according to claim 19,  
wherein the second laser beam has a wavelength of fundamental wave.
22. A laser irradiation method according to claim 19,  
wherein the beam spot formed on the surface of the processing object by the  
first laser beam is elliptical, rectangular, or linear.
- 20 23. A laser irradiation method according to claim 19,  
wherein the beam spot formed on the surface of the processing object by the  
second laser beam is elliptical, rectangular, or linear.
- 25 24. A laser irradiation method according to claim 19,  
wherein the first laser beam is emitted from a laser oscillator selected from the  
group consisting of an Ar laser, a Kr laser, an excimer laser, a  $\text{CO}_2$  laser, a YAG laser, a  
 $\text{Y}_2\text{O}_3$  laser, a  $\text{YVO}_4$  laser, a YLF laser, a  $\text{YAlO}_3$  laser, a glass laser, a ruby laser, an  
alexandrite laser, a Ti: sapphire laser, a copper vapor laser, and a gold vapor laser.
- 30 25. A laser irradiation method according to claim 19,  
wherein the second laser beam is emitted from laser oscillator selected from  
the group consisting of an Ar laser, a Kr laser, a  $\text{CO}_2$  laser, a YAG laser, a  $\text{Y}_2\text{O}_3$  laser, a  
 $\text{YVO}_4$  laser, a YLF laser, a  $\text{YAlO}_3$  laser, an alexandrite laser, a Ti: sapphire laser, and a  
35 helium-cadmium laser.

26. A laser irradiation method according to claim 19,  
wherein:

5 the processing object comprises a substrate having a thickness of “d” which is  
transparent to the first laser beam; and

an incident angle “ $\phi 1$ ” of the first laser beam to the surface of the processing  
object satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined as a length  
of a major axis or a minor axis of the beam spot formed on the surface of the  
processing object by the first laser beam.

10

27. A laser irradiation method according to claim 19,  
wherein:

the processing object comprises a substrate having a thickness of “d” which is  
transparent to the second laser beam; and

15

an incident angle “ $\phi 2$ ” of the second laser beam to the surface of the  
processing object satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined  
as a length of a major axis or a minor axis of the beam spot formed on the surface of  
the processing object by the second laser beam.

20

28. A laser irradiation method comprising the step of;

irradiating a processing object with a first pulsed laser beam having a  
wavelength of visible light or a shorter wavelength than that of visible light and a  
second continuous wave laser beam,

25

wherein when the first laser beam and the second laser beam are irradiated, a  
beam spot formed on a surface of the processing object by the first laser beam and a  
beam spot formed on the surface of the processing object by the second laser beam are  
overlapped.

30

29. A laser irradiation method according to claim 28,  
wherein the first laser beam has a wavelength of second harmonic.

30. A laser irradiation method according to claim 28,  
wherein the second laser beam has a wavelength of fundamental wave.

35

31. A laser irradiation method according to claim 28,

wherein the beam spot formed on the surface of the processing object by the first laser beam is elliptical, rectangular, or linear.

32. A laser irradiation method according to claim 28,  
5 wherein the beam spot formed on the surface of the processing object by the second laser beam is elliptical, rectangular, or linear.

33. A laser irradiation method according to claim 28,  
10 wherein the first laser beam is emitted from a laser oscillator selected from the group consisting of an Ar laser, a Kr laser, an excimer laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, a glass laser, a ruby laser, an alexandrite laser, a Ti: sapphire laser, a copper vapor laser, and a gold vapor laser.

34. A laser irradiation method according to claim 28,  
15 wherein the second laser beam is emitted from laser oscillator selected from the group consisting of an Ar laser, a Kr laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, an alexandrite laser, a Ti: sapphire laser, and a helium-cadmium laser.

20 35. A laser irradiation method according to claim 28,  
wherein:  
the processing object comprises a substrate having a thickness of "d" which is transparent to the first laser beam; and  
an incident angle " $\phi 1$ " of the first laser beam to the surface of the processing  
25 object satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined as a length of a major axis or a minor axis of the beam spot formed on the surface of the processing object by the first laser beam.

30 36. A laser irradiation method according to claim 28,  
wherein:  
the processing object comprises a substrate having a thickness of "d" which is transparent to the second laser beam; and  
an incident angle " $\phi 2$ " of the second laser beam to the surface of the  
processing object satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined  
35 as a length of a major axis or a minor axis of the beam spot formed on the surface of

the processing object by the second laser beam.

37. A method for manufacturing a semiconductor device comprising the steps of;

5 forming a semiconductor film on a insulating surface; and  
irradiating the semiconductor film with a first pulsed laser beam having a wavelength at which an absorption coefficient to the semiconductor film is  $1 \times 10^4 \text{ cm}^{-1}$  or more and a second continuous wave laser beam to crystallize the semiconductor film,

10 wherein when the first laser beam and the second laser beam are irradiated, a beam spot formed on a surface of the semiconductor film by the first laser beam and a beam spot formed on the surface of the semiconductor film by the second laser beam are overlapped.

15 38. A method for manufacturing a semiconductor device according to claim 37,  
wherein the first laser beam has a wavelength of second harmonic.

20 39. A method for manufacturing a semiconductor device according to claim 37,  
wherein the first laser beam has a wavelength of the fundamental wave.

37, 40. A method for manufacturing a semiconductor device according to claim  
25 wherein the beam spot formed on the surface of the semiconductor film by the first laser beam is elliptical, rectangular, or linear.

37, 41. A method for manufacturing a semiconductor device according to claim  
30 wherein the beam spot formed on the surface of the semiconductor film by the second laser beam is elliptical, rectangular or linear.

42. A laser irradiation method according to claim 37,  
35 wherein the first laser beam is emitted from a laser oscillator selected from the group consisting of an Ar laser, a Kr laser, an excimer laser, a CO<sub>2</sub> laser, a YAG laser, a

Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, a glass laser, a ruby laser, an alexandrite laser, a Ti: sapphire laser, a copper vapor laser, and a gold vapor laser.

43. A laser irradiation method according to claim 37,

5            wherein the second laser beam is emitted from laser oscillator selected from the group consisting of an Ar laser, a Kr laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, an alexandrite laser, a Ti: sapphire laser, and a helium-cadmium laser

10           44. A method for manufacturing a semiconductor device according to claim 37,

          wherein:

          the semiconductor is formed over a substrate comprising the insulating surface and having a thickness of "d" which is transparent to the first laser beam; and

15           an incident angle " $\phi 1$ " of the first laser beam to the surface of the semiconductor film satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined as a length of a major axis or a minor axis of the beam spot formed on the surface of the semiconductor film by the first laser beam.

20           45. A method for manufacturing a semiconductor device according to claim 37,

          wherein:

          the semiconductor is formed over a substrate comprising the insulating surface and having a thickness of "d" which is transparent to the second laser beam; and

25           an incident angle " $\phi 2$ " of the second laser beam to the surface of the semiconductor film satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined as a length of a major axis or a minor axis of the beam spot formed on the surface of the semiconductor film by the second laser beam.

30           46. A method for manufacturing a semiconductor device comprising the steps of;

          forming a semiconductor film on a insulating surface; and

          irradiating the semiconductor film with a first pulsed laser beam having a wavelength of visible light or a shorter wavelength than that of visible light and a  
35           second continuous wave laser beam to crystallize the semiconductor film,

wherein when the first laser beam and the second laser beam are irradiated, a beam spot formed on a surface of the semiconductor film by the first laser beam and a beam spot formed on the surface of the semiconductor film by the second laser beam are overlapped.

5

47. A method for manufacturing a semiconductor device according to claim 46,

wherein the first laser beam has a wavelength of second harmonic.

10

48. A method for manufacturing a semiconductor device according to claim 46,

wherein the first laser beam has a wavelength of the fundamental wave.

15

49. A method for manufacturing a semiconductor device according to claim 46,

wherein the beam spot formed on the surface of the semiconductor film by the first laser beam is elliptical, rectangular, or linear.

20

50. A method for manufacturing a semiconductor device according to claim 46,

wherein the beam spot formed on the surface of the semiconductor film by the second laser beam is elliptical, rectangular or linear.

25

51. A laser irradiation method according to claim 46,

wherein the first laser beam is emitted from a laser oscillator selected from the group consisting of an Ar laser, a Kr laser, an excimer laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, a glass laser, a ruby laser, an alexandrite laser, a Ti: sapphire laser, a copper vapor laser, and a gold vapor laser.

30

52. A laser irradiation method according to claim 46,

wherein the second laser beam is emitted from laser oscillator selected from the group consisting of an Ar laser, a Kr laser, a CO<sub>2</sub> laser, a YAG laser, a Y<sub>2</sub>O<sub>3</sub> laser, a YVO<sub>4</sub> laser, a YLF laser, a YAlO<sub>3</sub> laser, an alexandrite laser, a Ti: sapphire laser, and a helium-cadmium laser

35

53. A method for manufacturing a semiconductor device according to claim  
46,

wherein:

5 the semiconductor is formed over a substrate comprising the insulating surface  
and having a thickness of "d" which is transparent to the first laser beam; and

an incident angle " $\phi 1$ " of the first laser beam to the surface of the  
semiconductor film satisfies an inequality of  $\phi 1 \geq \arctan (W1/2d)$  when W1 is defined  
as a length of a major axis or a minor axis of the beam spot formed on the surface of  
the semiconductor film by the first laser beam.

10

54. A method for manufacturing a semiconductor device according to claim  
46,

wherein:

15 the semiconductor is formed over a substrate comprising the insulating surface  
and having a thickness of "d" which is transparent to the second laser beam; and

an incident angle " $\phi 2$ " of the second laser beam to the surface of the  
semiconductor film satisfies an inequality of  $\phi 2 \geq \arctan (W2/2d)$  when W2 is defined  
as a length of a major axis or a minor axis of the beam spot formed on the surface of  
the semiconductor film by the second laser beam.

20